THE IMPACT OF SCALLOP DREDGING ON A SOFT SEDIMENT COMMUNITY USING MULTIVARIATE TECHNIQUES

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Changes to benthic infauna caused by scallop dredging in Port Phillip Bay were examined experimentally using a BACI (Before, After, Control, Impact) design. Analysis of 150x0.1 m^2 grab samples obtained from 2 pre-dredging and 3 post-dredging periods are described. A diverse fauna of 204 invertebrate species and 49,044 individuals were surveyed. Bray-Curtis community dissimilarities were used to assess changes to community structure following dredging. Pair-wise comparisons of community dissimilarity between the control and dredge plots through time enabled a test of the statistical significance of change following dredging. Multi-dimensional scaling (MDS) was used to describe patterns of change following dredging.Statistically significant ($0.05<p<0.10$) changes to community structure were detected following dredging; ecological significance of these changes requires further analysis.

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The scallop industry in Port Phillip Bay is one of the most valuable commercial fisheries in Victoria and since its establishment in 1963 has produced up to 2000 tonnes, worth c.$20 million, annually. Scallop dredging in Port Phillip Bay is also widely regarded in the Victorian community as environmentally damaging. Many changes to the ecology of Port Phillip Bay, noted by fishermen and others, have been attributed (rightly or wrongly) to scallop dredging. In response to these concerns, a series of linked physical (Black & Parry, this memoir) and biological studies were initiated in 1991 to provide information on the impacts of scallop dredging.

Shellfish dredging may cause a range of impacts (Messieh et al.,1991, Jones,1992), but few are well-documented and biological impacts are particularly difficult to investigate because of the complexity of benthic communities and our limited knowledge of its natural variability (Messieh et al.,1991). Early studies (Caddy,1973, Butcher et al.,1981) of the effect of dredging on benthic communities were qualitatitive. More recent quantitative studies involve experimental manipulations, but often lack the statistical power to detect a small impact (Petersen et al.,1987, McShane,1981, Eleftheriou & Robertson,1992) or involve an inappropriate scale of impact, i.e. the experimentally dredged site is much smaller than would be dredged during normal commercial activities (McShane,1981, Eleftheriou & Robertson,1992). Furthermore, the impacts of scallop dredging depend upon the type of gear, amount of ground contact, type of seabed, depth, and strengths of currents (Jones,1992). The extent of biological impacts must also depend on the vulnerability of the benthic communities.

Most of the world's scallop dredge fisheries use different gear, operate on a range of substrate types and harvest scallops from different biological communities. Consequently, even if the effects of scallop dredging had been investigated in several of the world's fisheries, it would not be surprising if the impacts differed.

The species most likely to be impacted by scallop dredging are those which live near scallops, on or just beneath the sediment surface, and which are not mobile enough to avoid dredges. Thus epifaunal and infaunal communities appear to be the most vulnerable to scallop dredging. This paper examines the effect of scallop dredging on infaunal communities.

Dredge-related changes to the abundance and diversity of infaunal animals were examined using a BACI (Before After Control Impact) design (Stewart-Oaten et al.,1986). This design involves simultaneous sampling of two plots (one control, and one dredge) on a number of occasions, both before and after experimentally dredging the 'dredge' plot. On each sampling occasion differences between plots were assessed using the Bray-Curtis dissimilarity measure and a t-test was used to determine whether changes to this dissimilarity measure following dredging were statistically significant.

Changes to community structure following

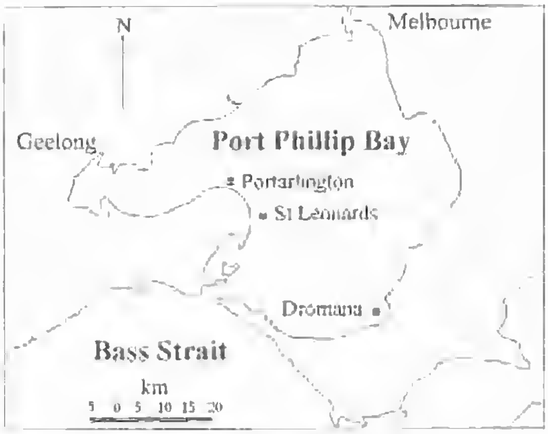

FIG.1. Map of Port Phillip Bay showing locations of main study areas used for scallop dredging trials.

dredging were also determined using multidimensional scaling (MDS). MDS provides a means of reducing large and complex data sets so that ecologically meaningful patterns and trends are more apparent and more readily interpreted (Gamito & Raffaelli,1992). MDS is a powerful ordination procedure that attempts to place some measure of similarity between objects into 2 or more dimensional space, such that distances between objects correspond closely to the input similarities. While the computational algorithm for MDS is complex the graphical representation is conceptually simple and easily communicated (Clarke,1993).

METHODS

Study Design

This study is part of a much larger study examining dredging-related changes to the abundance of benthic animals in 3 areas of Port Phillip Bay (St Leonards, Dromana and Portarlington) during 1991 (Parry & Currie,1992). We describe only studies in an area near St Leonards closed to all scallop dredging during 1991 (Fig.1).

Two adjacent 600mx600m experimental plots were located in 12–15m of water, c.2km offshore from St. Leonards. The more southerly was experimentally dredged by commercial vessels ('dredge' plot) and the other plot was left undredged ('control' plot).

The 'dredge' plot was commercially dredged over 3 days (16–18 July, 1991) by a fleet of 6 scallop vessels, using 3m wide 'Peninsula' dredges fitted with scraper/cutter bars that did not extend below the level of the skids (Hughes, 1973). Dredging was conducted for a maximum of 3 hours per day and coincided with periods in which there was a strong southerly tidal current that carried any dredging-related sediment away from the adjacent control site. The experimental plot was dredged with a moderately high fishing intensity compared to historical levels of fishing in Port Phillip Bay (Parry & Currie,1992). A 2x dredging intensity (where 2x refers to the number of times a dredge would on average pass over any point within the plot) was chosen as this level of fishing was common in areas with high densities of scallops and because any lower intensity would have left too large a proportion of the 'dredged' plot undredged.

On the first morning of the experimental dredging the plot to be dredged was marked out with 4 equidistant large buoys along each side of the 600m x 600m plot using a Furuno GP 500 GPS Navigator connected to a colour video plotter. This GPS provides an accuracy of 15–25m in 95% of fixes. Where inaccuracy exceeded 25m due to intentional degradation of the system (selective availability) this was obvious on the plotter. The buoys marked out three 200m x 600m lane ways directed E–W. Scallop vessels dredged these lane ways sequentially and fishermen were encouraged to dredge the whole area as evenly as possible. On the second and third days of dredging the buoys marking out the lane way boundaries were moved 50m N and S of their initial positions to minimise any undredged 'shadows' resulting from vessels not dredging near the buoys.

Estimates of the distribution and abundance of animals living within the sediments at each plot were determined from replicate 0.1 m^2 Smith-McIntyre grab samples. 15 samples were taken from each plot on 2 sampling dates before (13/5/91, 02/7/91) and 3 after (18/7/91, 9/8/91 & 31/10/91) the experimental dredging. Each plot was sub-divided into 12 equal sectors to facilitate stratified random sampling; one grab was taken at random from within each sector and the remaining 3 grab samples were taken at random across the plot. Samples were drained, weighed and a 70ml subsample retained for sediment analysis. All animals retained on a 1mm sieve were sorted to an optimal taxonomic level (generally species) under a dissecting microscope, before being counted.

Data Analysis

Differences between the control and dredge plots at each sampling period were examined

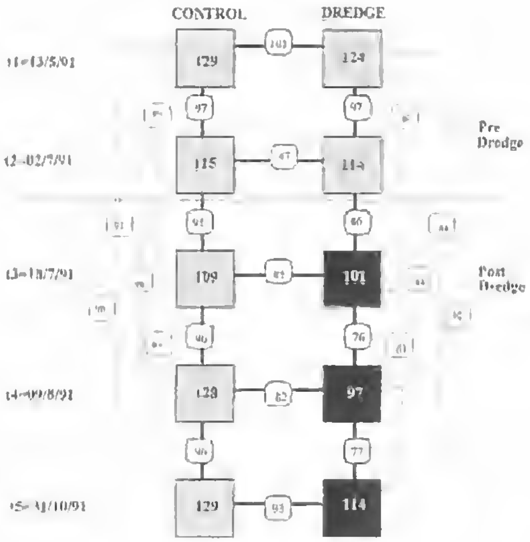

FIG.2. Schematic diagram showing differences between the number of species and number of shared species between different plots and sampling dates. Numbers in large squares are total number of species found on the control and dredge plot on each sampling date (t1–t5). Black squares show the number of species on the dredge site following the experimental dredging. Other numbers are the number of species shared between different plots and sampling times.

using Bray-Curtis (B-C) dissimilarity measures (Bray & Curtis,1957).

The Bray Curtis dissimilarity measure is:

$$\delta_{jk} = \frac{\sum_{i=1}^{s} \left| Y_{ij} - Y_{ik} \right|}{\sum_{i=1}^{s} (Y_{ij} + Y_{ik})}$$

where Y_{ij} = the score for the ith species in the jth sample; Y_{ik} = the score for the ith species in the kth sample; δ_{jk} = dissimilarity between the jth and kth samples summed over all s species. This particular measure was chosen because 1) it is not affected by joint absences 2) it gives more weighting to abundant species than rare ones, and 3) it has consistently performed well in preserving 'ecological distance' in a variety of simulations on different types of data (Faith et al.,1987).

On each sampling date the number of individuals of each species was calculated from the total number of individuals found on each plot, i.e. data from the 15 replicate grabs on each plot were pooled. Before calculating the B-C dissimilarity measures a double square root transformation was applied to the number of individuals of each species. This transformation prevents the abundant species from influencing the B-C dissimilarity excessively.

Five pairwise B-C dissimilarity measures comprising all control plot versus dredge plot comparisons for the 5 sampling periods (2 before and 3 after dredging) were used in the BACI analysis as proposed by Faith et al. (1991). The null hypothesis of no dredging effect is rejected if the mean of the B-C dissimilarity measures before dredging is lower than that after dredging, as judged by a t test.

Bray-Curtis dissimilarity measures calculated for all 10 plot*date (2 plots x 5 dates) combinations, resulted in a triangular matrix of dissimilarities which were used to map the plot*date inter-relationships in two dimensions. Hybrid multidimensional scaling (Belbin,1990) was employed for the ordination. This technique is a hybrid between metric and non-metric multidimensional scaling that attempts to combine the best features of each of the two techniques (Faith et al.,1987). By specifying a 'cut-value' less than the lowest dissimilarity measure, monotonic regression was used. The final configuration presented is the best solution (i.e. it exhibited the lowest 'stress' value ≈ least distortion) from 100 random starts.

RESULTS

204 invertebrate species and 49,044 individuals were encountered at the 2 St Leonards plots during the course of this study (Appendix); 86 (42%) were crustaceans, 53 (26%) polychaetes, 38 (19%) molluscs, and 27 (13%) members of other phyla.

At St Leonards, as is common with most other ecological communities (Preston,1948), there are a small number of abundant species and a large number of relatively rare species. The amphipod *Photis* sp.1 was the most abundant species and contributed 35% of the animals collected. Collectively the 20 most abundant species contributed 85% of the animals collected. By contrast, 105 species were represented in fewer than 10 of the 150 grab samples taken, and 38 species occurred in only one grab.

Changes in Species Numbers

The difference beween the total number of species sampled on the control and dredge plots was small before the dredging (5 at t1, 1 at t2; Figs 2,3) but increased following dredging (8 at t3, 31

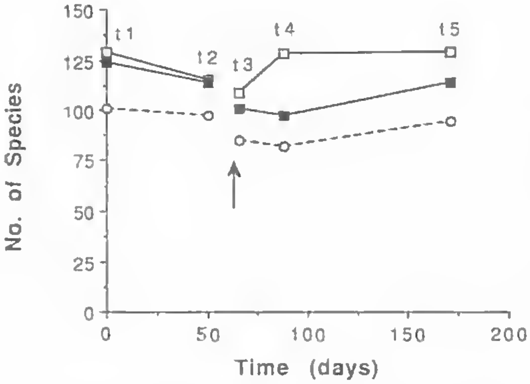

FIG.3. Total number of species recorded in 15 replicate grab samples taken from the control (□) and dredge (■) plots. The broken line indicates the number of species shared between the two plots. Arrow indicates when experimental dredging occurred.

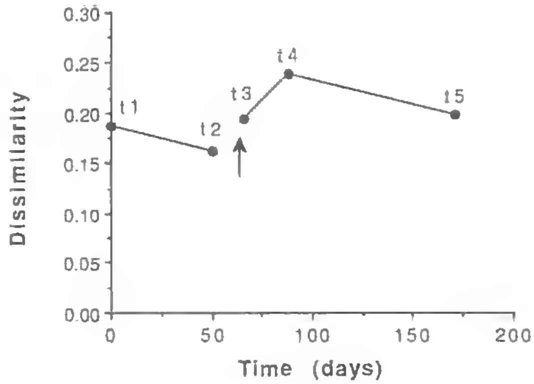

FIG.5. Bray-Curtis community dissimilarity between control and dredge plots before and after experimental dredging. Arrow indicates when experimental dredging occurred.

at t4, 15 at t5; Figs 2,3). The number of species shared between the control and dredge plots decreased from 101(t1) and 97(t2) before dredging to 85(t3), 82(t4) and 93(t5) following dredging (Figs 2,3). Other comparisons of the number of species shared between sampling times (Figs 2,3) also suggest that there was a reduction in the number of species following dredging. Over all 5 sampling times 72 species were always found on the control plot, but only 62 were always found on the dredge plot.

The mean difference in species number between both plots increased from 3 before dredging to 18 after dredging. A t-test of this increase in difference after dredging was significant at $0.05<p<0.10$. However the power of this test to detect a change of the observed magnitude was $P<0.30$ when $\alpha=0.05$.

Changes in Numbers of Individuals

The total number of individuals of all species sampled on the control plot and the dredge plot increased between t1 and t5, and particularly between t4 and t5 (Fig.4). This increase is the result of recruitment of juveniles, particularly of *Photis* sp.1, which accounts for approximately half of the overall increase during the study period (Currie & Parry, unpubl. data). However at each sampling time following dredging (t3–t5) the number of individuals on the dredge plot was

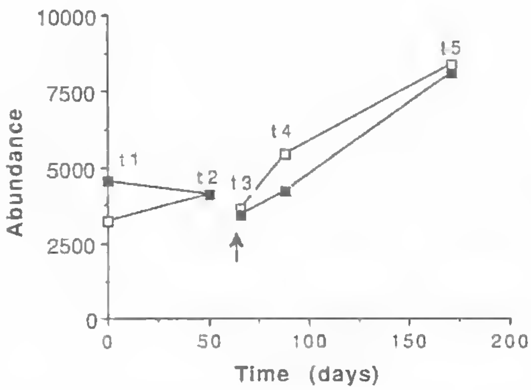

FIG.4. Total number of individuals in 15 replicate grab samples taken from the control (□) and dredge (■) plots. Arrow indicates when experimental dredging occurred.

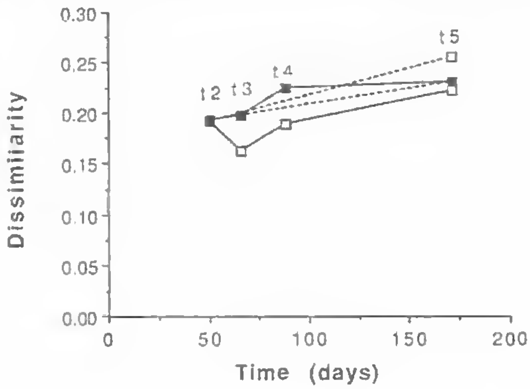

FIG.6. Bray-Curtis community dissimilarities between successive sampling dates (t1–t2, t2–t3, t3–t4, t4–t5, at control (□) and dredge (■) plots. Broken lines indicate t1–t5 comparisons for the control (□) and dredge (■) plots. t1 = 0 days.

lower than the number on the control plot, whereas before dredging there were either similar numbers on both plots (t2) or more on the dredge plot (t1, Fig.4).

Community Dissimilarity

Bray-Curtis dissimilarity measures between the control and dredge plots on the 5 sampling dates (Fig.5) increased significantly (t-test, $0.05<p<0.10$) from a mean of 0.175 before dredging to 0.211 after dredging, but the power of this test to detect a change of the observed magnitude was low ($P<0.32$ when $\alpha=0.05$). The first post-dredging sampling (t3) occurred on the last day of the experimental dredging and at this time there was minimal change in community dissimilarity, but the dissimilarity between the plots increased after 23 days (t4) before decreasing again after 88 days (t5). The increase in dissimilarity between t3 and t4 may have resulted from some moribund animals being collected on the dredge plot at t3, but these would not have been distinguishable from healthy animals in our analysis. Alternatively dredging may cause indirect ecological changes, such as increased vulnerability to predation, which take some time to have their maximum impact. The apparent increase in similarity of the plots between t4 and t5 is probably the result of recruitment of many additional species on both plots during this period. Recruitment of *Photis* sp.1 at this time makes only a small contribution to the B-C dissimilarity as a similar pattern of dissimilarity measures was obtained using only species presence-absence data (Currie & Parry, unpubl. data).

Comparison of Bray-Curtis dissimilarities between successive dates on the dredge and control plots (Fig.6) demonstrate that before dredging (t1–t2) there was little difference between successive samples. On the control plot following dredging there is a decrease in community dissimilarity in the periods t2–t3 and t3–t4, whereas on the dredge plot community dissimilarity increases in these same periods. On both the control and dredge plots there is an increase in dissimilarity in the period t4–t5 apparently due to recruitment of animals (particularly additional species) to both plots. Over the entire study period t1–t5 there was a larger increase in dissimilarity on the control plot than on the dredge plot. This appears to be the result of relatively lower recruitment of additional species on the dredge plot than on the control plot in the period following dredging, and suggests that dredging may reduce larval settlement.

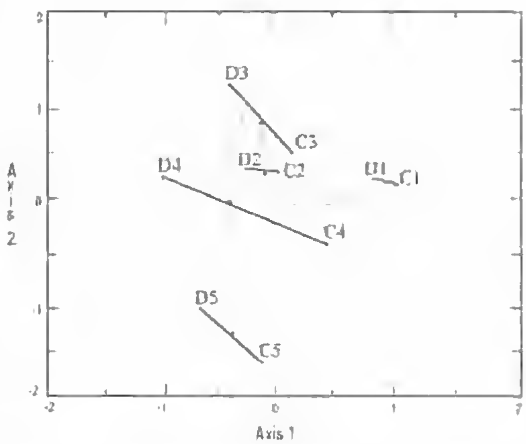

FIG.7. Two-dimensional scaling ordination mapping the relationships between benthic communities on the control (C) and dredge (D) sites before and after dredging. Numerals indicate the date of sampling (i.e. 1=13/5/91; 2=2/7/91; 3=18/7/91; 4=9/8/91; 5=31/10/91. Experimental dredging was conducted on 16, 17 and 18 July,1991. The solid lines connect control and dredge plots sampled on the same date. The broken line connects the different sampling times in sequence from t1 to t5.

Multidimensional Scaling (MDS)

The MDS ordination (Fig.7) maps the spatial and temporal changes in benthic community structure on the control and dredge plots before and after dredging. The stress coefficient of 0.153, indicates that the ordination is not unduly distorted (Clarke,1993), and a fair representation of the input dissimilarities in 2-dimensions.

The MDS ordination summarises many of the changes on the control and dredge plots noted above. Length of the lines in Fig.7 provide a measure of the dissimilarity of the dredge and control plots through time. Short lines connect the control and dredge plots at the first and second sampling dates (C1–D1 and C2–D2), but immediately following dredging the length of the lines increase, indicating an increase in dissimilarity between the control and dredge plots. The line connecting C4–D4 is the longest which indicates that on the second sampling date after dredging (t4) the plots are at their most different. The subsequent decrease in the length of the line at t5 (C5–D5) indicates that the plots are becoming more similar.

The broken line in Fig. 7 suggests that both the control and dredge plots follow a similar temporal trajectory which probably represents seasonal changes on both plots. The greatest temporal change occurs between t4 and t5, and coincides with the high levels of recruitment observed on both plots. Consideration of changes on the control plot also suggest that temporal changes are small between t1 and t4 (C1, C2, C3 and C4 group together) but are greater between t4 and t5 (C5 is distant from C1, C2, C3 and C4). The three samples taken on the dredge plot following dredging (D3, D4, D5) are the most divergent.

DISCUSSION

A statistically significant ($0.05<p<0.10$) increase in the Bray-Curtis dissimilarity between the control and dredge plots occurs following the experimental dredging. This increase indicates that scallop dredging changes the benthic community structure at St Leonards. This change in community structure appears to be the result of a decrease in species number (Figs 2,3) and a decrease in abundance of particular species (Fig.4).

No previous studies have demonstrated a significant impact of shellfish dredging on benthic infauna, partly at least due to the low statistical power of the tests involved (McShane,1981, Petersen et al.,1987). Low power results from the large spatial variability of benthic communities, the apparently small changes to the abundance of most species caused by dredging and from low intensity of sampling. The number of benthic samples already analysed in this study far exceeds the numbers analysed in previous studies, but still further pre-dredging and post-dredging samples must be analysed to confirm that our analysis is statistically robust. The usual statistical convention of $p<0.05$ has been relaxed in this study in an effort to more nearly balance type I and type II errors (Peterman,1990). Analysis of the effects of dredging on individual species is in progress and should enable identification of any characteristics of these species that may cause them to be vulnerable to dredging. This will greatly reduce the risk that the changes observed are due to an impact coincident with dredging ('demonic intrusion', Hulbert,1987), as will analysis of data collected at our other two study sites.

Assessment of the ecological significance of changes to community structure caused by dredging also remains to be determined. This assessment requires better estimates of the percentage change in abundance of various species, the persistence of these changes, and information on the trophic and other ecological consequences of the changes to the infauna. Studies in progress will provide this additional information and clarify the ecological importance of changes to benthic communities caused by scallop dredging.

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Appendix

Classification of the 204 benthic invertebrate species identified from 150 Smith–McIntyre grab samples taken at 'control' and 'dredge' plots off St. Leonards (38°10.06'S, 144°44.80'E. between the 13 May,1991 and 31 October,1991. Overall species rankings are given in ascending order of summed abundances. OBS = number of grab samples in which a species occurred.

CRUSTACEA

AMPHIPODA:

	SPECIES.	RANK	SUM	OBS.
FAM: AMPELISCIDAE.	*Byblis mildura* Lowry & Poore, 1985	9	1409	143
	Ampelisca euroa Lowry & Poore, 1985	63	44	33
FAM: CAPRELLIDAE.	*Metapratella cf. haswelliana* Haswell, 1884	151	3	3
FAM: COROPHIIDAE.	*Photis* sp.1	1	17004	146
	Ericanthanius sp.1	30	190	42
	Aara martani (Haswell, 1879)	141	4	1
FAM: CYPROIDEIDAE.	*Narapheanaides mullaya* Barnard, 1972	83	23	19
FAM: DEXAMINIDAE.	*Paradexamine lanacaura* Barnard, 1972	18	393	106
FAM: GAMMARIDAE.	*Melita* sp.1	68	36	27
	Maera mastersi (Haswell)	119	8	5
	Ceradacus serratus (Bate)	196	1	1
FAM: LEUCOTHOIDAE.	*Leucathae assimilis* Barnard, 1974	101	16	14
	Leucothoe sp.1	167	2	1
	Paraleucathae navaehallandiae Stebbing, 1899	166	2	2
FAM: LILJEBORGIIDAE.	*Liljebargia* sp.1	32	176	70
	Liljebargia sp.2	132	6	5
FAM: LYSIANASSIDAE.	*Endevoura mirabilis* Chilton, 1921	98	17	6
	Hippamedan denticulatus (Bate)	58	51	21
	Amaryllis macraphthalmus Haswell, 1879	85	22	15
	Lysianassid sp.1	122	8	6
	Lysianassid sp.2	144	4	3
	Lysianassid sp.3	191	1	1
	Lysianassid sp.4	74	29	1
FAM: MELPHIDIPPIDAE.	*Cheiracratus bassi* (Stebbing)	96	17	9
FAM: OEDICEROTIDAE.	*Oediceratid* sp.1	13	720	102
	Oediceratid sp.2	143	4	4
FAM: PHOXOCEPHALIDAE.	*Birubius babaneekus* Barnard & Drummond, 1978	71	31	23
	Phaxacephalus kukathus Barnard & Drummond, 1978	73	30	22
	Bralgus tattersalli (Barnard)	72	30	22
	Birubius panamunus Barnard & Drummond, 1976	84	22	18
	Birubius cartaa Barnard & Drummond, 1978	111	11	10
FAM: PODOCERIDAE.	*Dulichia* sp.1	57	52	24

ISOPODA:

FAM: ANTHURIDAE.	*Amakusanthura pimelia* Poore & Lew Ton, 1985	134	6	6
	Haliaphasma cribense Poore, 1975	76	27	8
	Haliaphasma canale Poore, 1975	117	9	7
FAM: ASTACILLIDAE.	*Neastacilla deducta* (Hale)	203	1	1
FAM: EURYDICIDAE.	*Natatalana waadjanesi* (Hale)	61	50	28
	Natatalana carpulenta (Hale)	16	518	132
FAM: PARANTHURIDAE.	*Bullawanthura pambula* Poore, 1978	8	1871	148
	Leptanthura diemenensis (Haswell, 1884)	133	6	3
FAM: SEROLIDAE.	*Heteraseralis australiensis* (Beddard)	153	3	3
FAM: SPHAEROMIDAE.	*Exasphaerama* sp. 1	131	6	4

CUMACEA:

FAM: BODOTRIIDAE.	*Glyphacuma bakeri* (Hale)	202	1	1
FAM: DIASTYLIDAE.	*Gynadiastylis ambigua* Hale, 1946	42	91	35
	Dimarphastylis cattani Hale, 1936	3	2324	143
	Dicaides fletti Hale, 1946	100	16	13
FAM: LEUCONIDAE.	*Hemileucan levis* Hale, 1945	44	90	28

Crustacea cont.

	SPECIES.	RANK	SUM	OBS.
DECAPODA:				
FAM: ALPHEIDAE.	*Alpheus euphrasyne* (de Man)	195	1	1
	Athanapsis sp.1	201	1	1
FAM: CALLIANASSIDAE.	*Callianassa arenasa* Poore, 1975	75	29	25
	Upagebia dramana Poore & Griffin, 1979	104	15	9
FAM: CRANGONIDAE.	*Pantophilus intermedius* (Bate)	121	8	7
FAM: DISCIADIDAE.	*Discias* sp.1	199	1	1
FAM: GALATHEIDAE.	*Galathea australiensis* (Stimpson)	165	2	2
	Munida haswelli (Henderson)	189	1	1
FAM: GONEPLACIDAE.	*Hexapus* sp.1	129	7	6
FAM: HIPPOLYTIDAE.	*Hippolyte tenuirostris* (Bate)	142	4	3
FAM: HYMENOSOMATIDAE.	*Halicarcinus rostratus* (Haswell)	35	130	70
	Halicarcinus ovatus (Stimpson)	79	26	17
FAM: LEUCOSIIDAE.	*Phlyxia intermedia* Miers, 1886	52	63	47
	Philyra undecimspinasa (Kinahan)	108	14	10
FAM: MAJIDAE.	*Majid* sp.1	193	1	1
	Thacanaphrys spatulifer (Filhol)	188	1	1
FAM: PASIPHAEIDAE.	*Leptochela* sp.1	200	1	1
FAM: PINNOTHERIDAE.	*Pinnatheres hickmani* (Baker)	194	1	1
FAM: PORCELLANIDAE.	*Palyonyx transversus* (Haswell)	113	10	9
FAM: PORTUNIDAE.	*Nectacarcinus integrifrans* (Latreille, 1825)	197	1	1
FAM: SERGESTIDAE.	*Leucifer* sp.1	97	17	12
FAM: XANTHIDAE.	*Heterapilumnus fimbriatus* (Milne Edwards)	190	1	1
MYSIDACEA:				
FAM: MYSIDAE.				
SF: GASTROSACCINAE.	*Paranchialina angusta* (Sars)	29	193	56
SF: SERIELLINAE.	*Siriella vincenti* (Tattersall)	45	85	14
SF: MYSINAE.	*Australomysis incisa* (Sars)	64	42	20
	Tenagamysis sp.1	27	213	54
TANAIDACEA:				
FAM: APSEUDIDAE.	*Apseudes* sp.1	92	18	14
FAM: KALLIAPSEUDIDAE.	*Kalliapseudes* sp.1	17	477	122
FAM: TANAIDAE.	*Tanaidae* sp.1	168	2	2
OSTRACODA:				
S/O: CYPRIDINIFORMES.				
FAM: CYPRIDINIDAE.	*Cypridinidae* sp.1	62	49	40
S/O: CYLINDROLEBERIDIDAE.	*Bathyleberis* sp.1	67	37	26
S/O: CYLINDROLEBERIDIDAE.	*Empaulsenia* sp.1	34	132	79
FAM: SARSIELLIDAE.	*Sarsiellid* sp.1	192	1	1
FAM: PHILOMEDIDAE.	*Philamedid* sp.1	198	1	1
COPEPODA:				
ORDER: CALANOID.	*Labidocera* sp.1	88	21	12
ORDER: CYCLOPOIDA.	*Cyclapaid* sp.1	152	3	2
NEBALIACEA:				
FAM: NEBALIIDAE.	*Nebalia* sp.1	120	8	7
LARVAE:	*Caridea larvae* sp.1	137	5	3
	Brachyura zaea sp.1	163	2	2

	SPECIES.	RANK	SUM	OBS.
ECHINODERMATA				
CLASS: HOLOTHUROIDEA:				
FAM: CHIRIDOTIDAE.	*Trachadata allani* (Joshua, 1912)	21	342	105
FAM: SYNAPTIDAE.	*Leptasynapta dalabrifera* (Stimpson, 1855)	116	9	5
SUBCLASS: OPHIUROIDEA:				
FAM: AMPHIURIDAE.	*Amphiura elandiformis* Clark, 1966	33	156	85
	Ophiacentrus pilasus (Lyman)	55	56	35
	Amphiphalis squamata (D. Chiaje, 1828)	115	9	7
FAM: OPHIURIDAE.	*Ophiura kinbergi* Ljungman, 1866	51	63	46
CLASS: ECHINOIDEA:				
FAM: LOVENIIDAE.	*Echinacardium cardatum* (Pennant, 1777)	38	120	70
CHORDATA				
ASCIDIACEA:				
FAM: ASCIDIIDAE.	*Ascidia sydneyensis* Stimpson, 1885	109	13	9
	Ascidiella aspersa (Müller)	123	8	5
FAM: STYELIDAE.	*Cnemidacarpa etheridgii* (Hardman)	170	2	2
FAM: PYURIDAE.	*Pyura stalanifera* (Heller, 1878)	171	2	2
NEMERTINEA	*Nemertean* sp.1	43	90	54
	Nemertean sp.2	50	65	36
	Nemertean sp.3	78	26	15
	Nemertean sp.4	180	1	1
	Nemertean sp.5	77	26	22
	Nemertean sp.6	66	37	22
	Nemertean sp.7	70	33	17
	Nemertean sp.8	127	7	4
	Nemertean sp.9	157	2	2
PORIFERA	*Demaspangiae* sp.1	172	1	1
PHORONIDA	*Pharanis* sp.1	82	23	10
PROTOZOA				
FORAMINIFERA:				
FAM: MILIOTIDAE.	*Triloculina affinis* d'Orbigny, 1826	11	1262	129
	Quinquelaculina sp.1	90	19	13
	Quinquelaculina sp.2	118	8	7
FAM: POLYMORPHINIDAE.	*Guttulina* sp.1	164	2	2
ECHIURA	*Metabonellia haswelli* (Johnston & Tiegs)	169	2	2
	Anelassarhynchus porcellus (Fisher)	204	1	1

ANNELIDA

POLYCHAETA:

	SPECIES.	RANK	SUM	OBS.
FAM: AMPHERETIDAE.	*Ampharete* sp.1	14	672	105
FAM: CAPITELLIDAE.	*Capitellid* sp.1	39	106	20
	Natomastus sp.1	102	15	14
	Notomostus sp.2	145	3	3
FAM: CHAETOPTERIDAE.	*Chaetapterus variopedotus* (Renier, 1804)	110	11	11
FAM: CIRRATULIDAE.	*Chaetozane* sp.1	20	364	106
	Tharyx sp.1	106	14	14
FAM: DORVILLEIDAE.	*Darvillea australiensis* (M^{c}Intosh, 1885)	59	50	29
FAM: EUNICIDAE.	*Marphysa* sp.1	40	105	51
FAM: FLABELLIGERIDAE.	*Diplacirrus* sp.1	47	74	52
FAM: GLYCERIDAE.	*Glycera cf. omericana* Leidy, 1855	28	202	110
FAM: GONIADIDAE.	*Gonioda emerita* Audouin & Milne Edwards, 1833	31	183	97
	Ophioglycero sp.1	174	1	1
FAM: HESIONIDAE.	*Nerimyra langicirrota* Knox & Cameron, 1971	60	50	39
	Hesionid sp.2	178	1	1
FAM: LUMBRINERIDAE.	*Lumbrineris latreilli* Audouin Milne Edwards, 1834	10	1353	145
FAM: MAGELONIDAE.	*Magelana cf. dakini* Jones, 1978	93	17	15
FAM: MALDANIDAE.	*Clymenello* sp.1	65	37	25
	Asychis sp.1	25	247	109
	Maldanid sp.1	125	7	7
FAM: NEPTHYIDAE.	*Nephtys inarnata* Rainer & Hutchings, 1977	6	2157	138
FAM: NEREIDAE.	*Simplisetia aequisetis* Hutchings & Turvey, 1982	80	25	22
	Olganereis edmandsi (Hartman)	86	21	18
	Platynereis dumerilii antipada Hartman, 1954	89	19	9
	Ceratanereis sp.1	176	1	1
FAM: OPHELLIDAE.	*Armandia cf. intermedia* Fauvel, 1902	36	126	57
	Polyophthalmus pictus (Dujardin, 1839)	156	2	2
FAM: ORBINIIDAE.	*Leitoscolopolos bifurcatus* (Hartman, 1957)	15	585	118
FAM: PARAONIDAE.	*Aricideo* sp.1	5	2290	126
	Paraonid sp.1	19	378	74
	Paraonis grocilis gracilis (Tauber, 1879)	124	7	4
FAM: PECTINARIIDAE.	*Pectinoria cf. antipoda* Schmarda, 1861	126	7	7
FAM: PHYLLODOCIDAE.	*Phyllodoce* sp.1	37	121	78
	Eulalia sp.1	154	2	1
FAM: POLYNOIDAE.	*Paralepidanotus ampulliferus* (Grube, 1878)	114	9	8
	Hormathoe sp.1	23	307	118
	Harmothoe spinasa Kinberg, 1855	87	21	11
	Malmgrenio microscala (Kudenov)	130	6	6
FAM: SABELLIDAE.	*Jasmineira* sp.1	12	1062	102
	Myxicola infundibulum (Renier, 1804)	179	1	1
FAM: SERPULIDAE.	*Serpulid* sp.1	175	1	1
FAM: SIGALIONIDAE.	*Sigalion* sp.1	173	1	1
FAM: SPIONIDAE.	*Prionaspio coorilla* Wilson, 1990	4	2316	108
	Prianaspia yuriel Wilson, 1990	91	18	15
	Palydara sp.1	177	1	1
	Laanice quadridentata Blake & Kudenov, 1978	155	2	2
FAM: SYLLIDAE.	*Syllis* sp.1	146	3	3
FAM: TEREBELLIDAE.	*Amaenna trilabata* Hutchings & Glasby, 1986	46	77	33
	Terebellid sp.1	112	10	8
	Eupolymnia kaorangia Hutchings & Glasby, 1988	105	14	5
FAM: TRICHOBRANCHIDAE.	*Terebellides* sp.1	22	318	97
	Artacamello dibranchiata Knox & Cameron, 1971	2	3149	135

MOLLUSCA:

	SPECIES.	RANK.	SUM.	OBS.
FAM: AGLAJIDAE.	*Aglajo torongo* Allan, 1933	95	17	14
FAM: ARCIDAE.	*Anodoro tropezio* (Deshayes, 1840)	99	16	14
FAM: CARDIIDAE.	*Pratulum thetidus* (Lamarck, 1819)	107	14	11
	Fulvio tenuicastoto (Lamarck, 1819)	160	2	2
FAM: CORBULIDAE.	*Corbula cf. coxi* Pilsbury, 1897	7	1974	146
FAM: CYAMIIDAE.	*Cyomiomactro communis* Hedley, 1905	162	2	2
FAM: DORIDIDAE.	*Doris comeroni* (Allan, 1947)	187	1	1
FAM: EULIMIDAE.	*Strombiformis topozioco* (Hedley, 1908)	158	2	1
FAM: GONIODORIDIDAE.	*Okenio sp. nov.*	181	1	1
FAM: HAMINEIDAE.	*Lilao brevis* (Quoy & Gaimard, 1834)	41	92	58
FAM: HIATELLIDAE.	*Hiatello australis* (Lamarck, 1818)	69	34	4
	Hiatella subuloto (Gatliff & Gabriel, 1910)	159	2	2
FAM: KELLIIDAE.	*Melliteryx acupunctum* (Hedley, 1902)	94	17	11
FAM: MACTRIDAE.	*Moctro jocksonensis* (Smith, 1885)	128	7	7
FAM: MONTACUTIDAE.	*Mysella danacifarmis* Angas, 1878	136	5	5
FAM: MURICIDAE.	*Bedevo poivae* (Crosse, 1864)	140	4	2
FAM: MYTILIDAE.	*Amygdolum beddomi* Iredale, 1924	135	5	5
	Musculus ulmus Iredale, 1936	149	3	3
FAM: NASSARIDAE.	*Nassarius (Zeuxis) pyrrhus* (Menke, 1843)	53	62	40
FAM: NATICIDAE.	*Polinices sordidus* (Swainson, 1821)	139	4	3
	Sinum zonole (Quoy & Gaimard, 1833)	182	1	1
FAM: NUCULIDAE.	*Nucula pusilla* Angas, 1877	49	71	36
	Nuculo abliquo (Lamarck, 1819)	3	15	14
FAM: OSTREIDAE.	*Ostreo ongasi* Sowerby, 1871	184	1	1
FAM: PECTINIDAE.	*Pecten fumatus* Reeve, 1852	81	23	17
FAM: PERIPLOMATIDAE.	*Offadesma ongasi* (Crosse & Fischer, 1864)	54	57	41
FAM: PHILINIDAE.	*Philine ongosi* (Crosse & Fischer, 1865)	48	72	52
FAM: PTERIIDAE	*Electramo georgiono* (Quoy & Gaimard, 1835)	150	3	3
FAM: PYRAMIDELLIDAE.	*Pyrgiscus fusco* (A Adams, 1853)	148	3	3
FAM: SEMELIDAE.	*Theoro cf. lubrico* H & A Adams, 1866	24	269	78
FAM: SOLENIDAE.	*Solen voginoides* (Lamarck, 1818)	183	1	1
FAM: TELLINIDAE.	*Tellino (Mocomono) morioe* (Tenison Woods, 1875)	185	1	1
FAM: TROCHIDAE.	*Ethminolio vitilignea* (Menke, 1843)	147	3	3
FAM: VENERIDAE.	*Chioneryx cardioides* (Lamarck, 1818)	26	228	98
	Collanoitis disjecta (Perry, 1811)	138	4	4
	Placamen placida (Philippi, 1835)	186	1	1
	Venerupis sp. Lamarck, 1818	161	2	2